Case Study

Creative Inspection for Water Ingress in Composite Aircraft Material

FLIR Systems

Thermal imaging cameras are a great tool to inspect composite material aircraft parts for moisture ingress. The ideal time to do this is within one hour after the airplane has landed, because then the temperature differences between the composite material and frozen water are the greatest, and there is enough thermal imaging contrast. But how do you inspect for moisture when there is no thermal contrast, with an airplane part that has been stationary in a hangar for several days? The answer is: with lots of creativity and with thermal imaging cameras from FLIR.

Ralf Grispen: "For inspection jobs like these, but also for other applications, we like to rely on the FLIR P660 camera, because it is an advanced camera which has proven its value over the many years we have been using it."

Composite materials like carbon fibre are increasingly popular for the construction of aircraft, because these materials are very strong and lightweight at the same time. However, water ingress into the honeycomb structure of composite aircraft parts is dangerous and not always avoidable. Tiny cracks in the composite material might allow water to enter the structure. At high altitude, where the air is a lot cooler, this water will be turned into ice. This will cause the composite material to expand, making the honeycomb cell bonding weaker. If this process is repeated many times, the composite honeycomb structure becomes damaged, which might impact the airplane's stability.

Thermal Imaging for Water Ingress Inspection

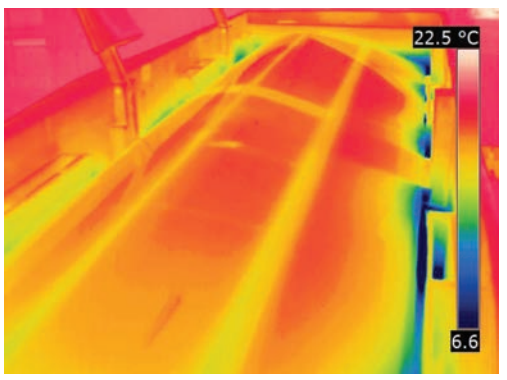
Dutch thermography specialist Thermografisch Adviesbureau BV has a lot of experience with thermal inspection of water ingress in airplane structures. "Thermal imaging cameras allow you to inspect the aircraft for water ingress very fast and in a non-contact mode," said Ralf Grispen, Level I and II certified thermographer at Thermografisch Adviesbureau BV. "This is in stark contrast with direct contact methods, which for example include tapping the surface with a hammer and trying to detect auditory differences. These methods are rather inaccurate and time-sensitive."

"Thermal imaging allows you to get an overall picture of the composite structure by means of temperature differences which clearly indicate the presence of moisture. Another advantage of using thermal imaging cameras is that it allows you to report, analyse and interpret the hidden moisture extensively afterwards."

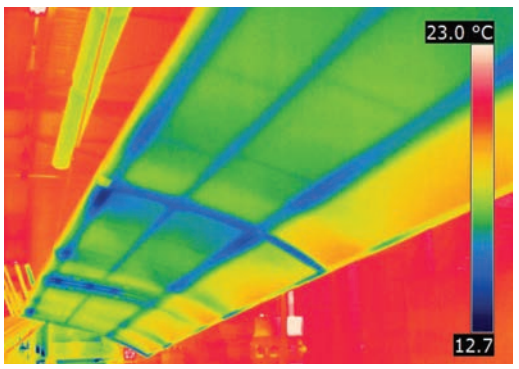
Thermal Contrast

"The best time to perform a thermal imaging inspection is within one hour after the aircraft has landed," said Ralf Grispen. "That's when you have the biggest thermal contrast between the composite material and the water ingress."

Water and composite materials have different thermal properties. When out of thermal balance, after a heating or cooling process, a temperature difference is observed between water and composite. With a thermal imaging camera, you can observe the temperature distribution on the composite surface very clearly. However, a good thermal contrast is not always a given. One assignment that Thermografisch Adviesbureau BV got attributed in 2015 was the inspection of a composite wing flap of a Boeing aircraft which had been repaired by a Dutch Maintenance, Repair and Operations (MRO) company, and which had been lying at a closed-off hangar for a number of days.



Overview of the upper skin of the outboard flap: the thermal picture reveals no water ingress. The blue colour indicates the presence of dry ice in the wooden case and the airflow from the freezer unit.



Overview of the lower skin of the outboard flap: the thermal picture reveals no water ingress. The blue colour indicates the airflow from the freezer unit.

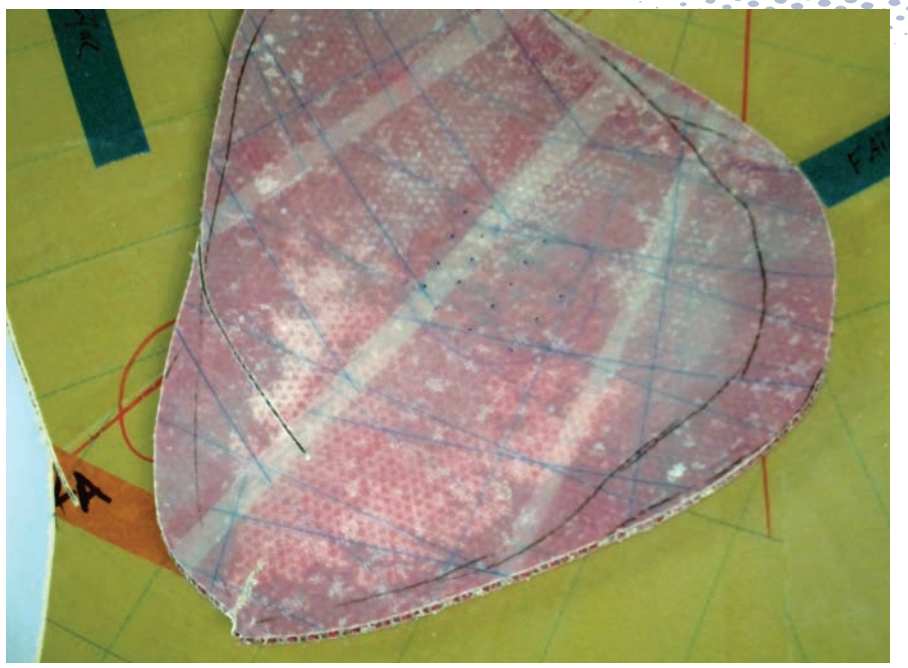
"The difficulty with this type of assignment was that due to the closed-off hangar environment, there was no sufficient temperature difference between the water and the composite material, something we usually have when we perform inspections right after landing. And since there was no sufficient thermal contrast, we would have to create a thermal contrast ourselves in one way or another," said Ralf Grispen.

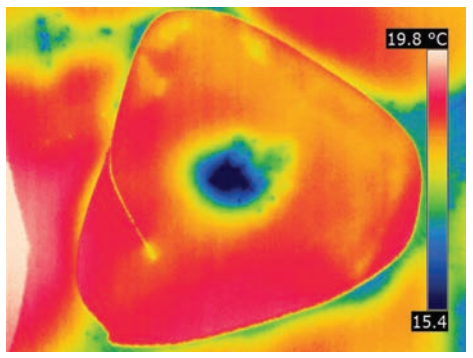
One way of creating a thermal contrast is by using a heat excitation source to bring the object to a certain temperature. This is what is commonly referred to as active thermography. Possible defects can then be detected after the thermal excitation by looking at the thermal transient for an anomalous heat transfer response. Although active thermography is an accurate and proven methodology, it was not very practical in this case.

"To prepare an active thermography set-up for a flap would have been very time-consuming for us and therefore also not very cost-effective," said Ralf Grispen. "Although we believe active thermography works, it was not the right choice for this job."

A Special 'case' of Thermography

To be able to create the required thermal contrast, the team of Thermografisch Adviesbureau BV needed to be creative. The inspection was done entirely in conformity with the OEM NDT manual. To create a temperature difference, the team decided to cool the flap down by putting it into the transport case and using a mobile freezer unit and dry ice. This way, it was possible to simulate the circumstances and temperature differences





A composite test specimen was injected with water: this is clearly visible on the thermal image.

which normally occur right after landing the aircraft. By using a crane, it was possible to move the flap around, so all parts of the flap could be carefully inspected.

"We wanted to confirm for ourselves and for the customer that this methodology works," said Ralf Grispen. "Therefore, we prepared a small test specimen, made from the same composite material as the Boeing flap, which we deliberately injected with water. This would serve as our reference."

The thermal inspection was done successfully with a FLIR P660 thermal imaging camera. And although no moisture or water was found on the composite parts of the flap, the thermal image of the reference specimen clearly showed the presence of water.

Proven Thermal Imaging Quality

"For inspection jobs like these, but also for other applications, we like to rely on the FLIR P660 camera, because it is an advanced camera which has proven its value over the many years we have been using it," said Ralf Grispen. "The P660 camera images are looking great and the thermal detail is excellent."

"In my opinion, thermal imaging will become even more important in the future in the aerospace industry, especially when you think of the fact that more and more composite materials are used for today's airplanes. Thermal imaging is a great way to look for water ingress in composite materials, be it as part of a routine inspection within an hour after landing, or in a specific inspection set-up like we have created in this case. Certainly in a critical era like today, where the aerospace industry is confronted with high price pressure and the need to combine low cost with high safety, thermal imaging is an excellent, cost-effective way to help guarantee the quality of the aircraft and the safety of its passengers."